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Spatiotemporal Trends of Hepatitis C in Slovakia: A Joinpoint and GIS-Based Analysis (2015–2025)

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Спатіотемпоральні тренди гепатиту С у Словаччині: аналіз на основі Joinpoint та ГІС (2015–2025)

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Introduction

Epidemiological significance of hepatitis C

Monitoring long-term epidemiological trends is essential for understanding the dynamics of infectious diseases and for guiding public health interventions. Hepatitis C remains a significant public health concern despite the availability of highly effective antiviral therapy, particularly due to ongoing transmission and delayed diagnosis [1; 2].

Incidence and prevalence indicators provide valuable insights into the development of the disease over time. Analysis of temporal trends enables the identification of changes in transmission patterns, which may be influenced by variations in testing strategies, healthcare accessibility, and external factors such as the COVID-19 pandemic [3].

Importance of spatial analysis and regional disparities

In addition to temporal dynamics, the spatial distribution of cases represents an important component of epidemiological surveillance. Regional differences in disease occurrence may reflect disparities in population structure, socioeconomic conditions, and access to preventive and diagnostic services. Identifying geographical clustering of cases is therefore crucial for the implementation of targeted micro-elimination strategies [4; 5].

Recent studies have highlighted increasing or fluctuating trends in hepatitis C incidence across European countries, emphasising the need for continuous monitoring and evaluation of national and regional epidemiological data [6].

The present study aims to analyse long-term trends in hepatitis C incidence in Slovakia over a ten-year period using Joinpoint regression analysis and to assess the spatial distribution of cases in selected regions. By combining temporal and spatial approaches, this study provides a comprehensive overview of the epidemiological situation and supports evidence-based public health decision-making.

Research gap and study rationale

Despite the availability of epidemiological data on hepatitis C in Slovakia, comprehensive analyses combining both temporal and spatial approaches remain limited. In particular, there is a lack of studies integrating surveillance data with community-based screening in marginalised populations. This gap highlights the need for a more complex analytical framework to better understand the dynamics of HCV transmission at both national and regional levels.

The aim of this study was to analyse spatiotemporal trends in hepatitis C incidence in Slovakia over a ten-year period and to assess the spatial distribution of cases across selected regions.

The study also aimed to explore the role of community-based screening in improving early detection of HCV infection among marginalised populations.

Object, materials and methods

The study had a descriptive-analytical design focused on the evaluation of hepatitis C virus (HCV) epidemiology in Slovakia, with particular emphasis on the Banská Bystrica Region.

Data on the incidence of chronic hepatitis C for the period 2015–2025 were obtained from the national Epidemiological Information System (EPIS). Population data used for the calculation of incidence rates per 100,000 population were derived from official statistical sources.

Temporal trends in HCV incidence were analysed using Joinpoint regression analysis, allowing the identification of significant changes over time. Annual percentage change (APC) was calculated to describe the direction and magnitude of trends, with statistical significance set at $p < 0.05$.

Spatial analysis was conducted to assess the geographical distribution of hepatitis C cases, with a focus on identifying regional disparities and potential clustering in the Banská Bystrica Region.

Anti-HCV testing was performed using a rapid diagnostic test (STANDARD Q HCV Ab). All analyses were conducted using R software (R Project), and the results were interpreted in the context of national and regional epidemiological data.

The study was conducted in accordance with ethical principles, and participation was voluntary and anonymous.

Selection of study sites and community-based screening

Study locations were selected based on data from the Atlas of Roma Communities (2019), which served as a framework for identifying marginalised populations in the Banská Bystrica Region. From the total of 13 districts, selected high-risk areas included Lučenec, Fiľakovo, Veľký Krtíš, Rimavská Sobota and Revúca.

Based on these data, specific municipalities and localities with the presence of marginalised communities were identified. Field activities were conducted in cooperation with local community centres, municipal outreach workers, and the organisation Healthy Regions.

Community-based screening activities were carried out between 2024 and 2025. Anti-HCV antibody testing was performed by trained healthcare personnel using capillary blood sampling (finger-prick) and a rapid diagnostic test (STANDARD Q HCV Ab, SD Biosensor, Republic of Korea), in accordance with the manufacturer's instructions.

In addition to testing, educational activities focused on hepatitis prevention and awareness were conducted, and data were collected through an anonymous questionnaire survey.

Data processing. Data on confirmed HCV cases for the period 2022–2025 were obtained from the Infectious Diseases Department in Lučenec. Aggregated data on anti-HCV positive individuals from marginalised communities were also provided by the Community Centre in Lučenec.

All data were processed in anonymised and aggregated form.

Participants with a positive anti-HCV result were informed about the need for further diagnostic evaluation and were referred to specialised healthcare services.

The study did not require formal approval from an ethics committee, as it was based on anonymised, non-interventional data collection and public health screening activities. No identifiable personal data were collected.

Spatial visualisation and mapping were performed using QGIS software version 3.40.7.

Temporal trends were analysed using Joinpoint Regression Program version 5.0.2 developed by the National Cancer Institute.

Research results

Prevalence and Incidence

The prevalence of anti-HCV positivity increased from 2.0 % in 2024 to 16.0 % in 2025, indicating a marked rise in detected cases within the tested population. This increase may reflect improved case detection through intensified screening activities in marginalised communities (Figure 1).

The incidence of chronic hepatitis C increased from 15.7 per 100,000 population in 2024 to 17.8 per 100,000 population in 2025, indicating a rising trend in the region. This finding suggests a potential increase in transmission or a recovery of diagnostic activities following previous disruptions, particularly during the COVID-19 pandemic (Figure 2).

Joinpoint regression

Joinpoint regression analysis identified one significant change point, with a decreasing trend in 2015–2018 (APC −37.6 %; $p < 0.05$) and a statistically significant increasing trend in 2018–2025 (APC +37.7 %; $p < 0.05$) (Figure 3).

Spatial distribution of HCV cases in the Banská Bystrica Region

The spatial distribution of HCV infection in the Banská Bystrica Region is based on cases identified

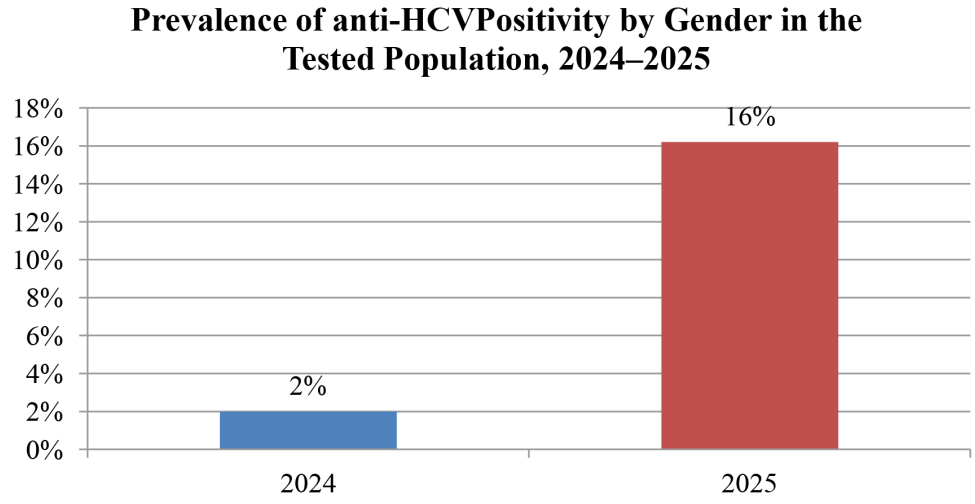

Fig. 1. Prevalence of anti-HCV positivity in the tested population, 2024–2025

Source: author's own processing

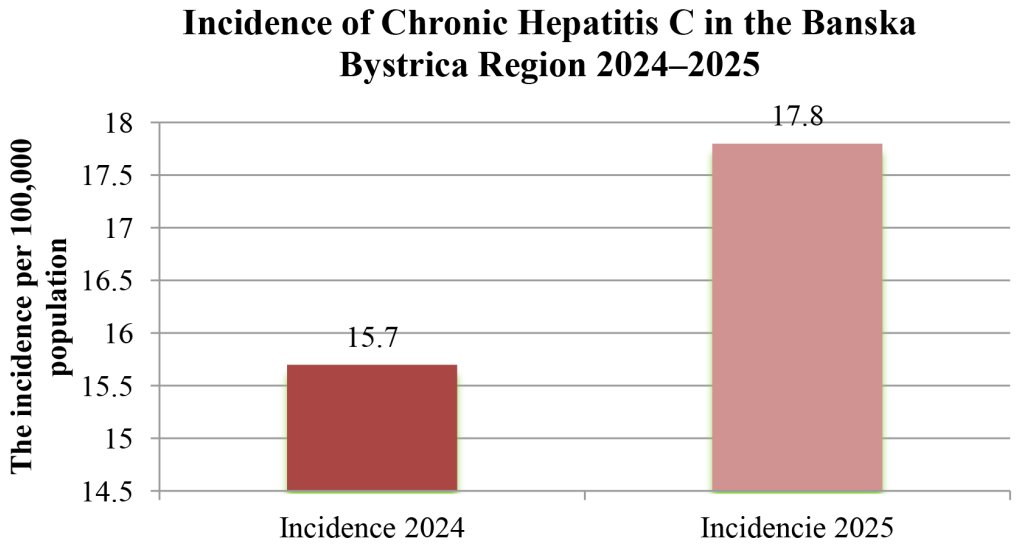

Fig. 2. Incidence of chronic hepatitis C in the Banská Bystrica Region, 2024–2025

Source: author's own processing

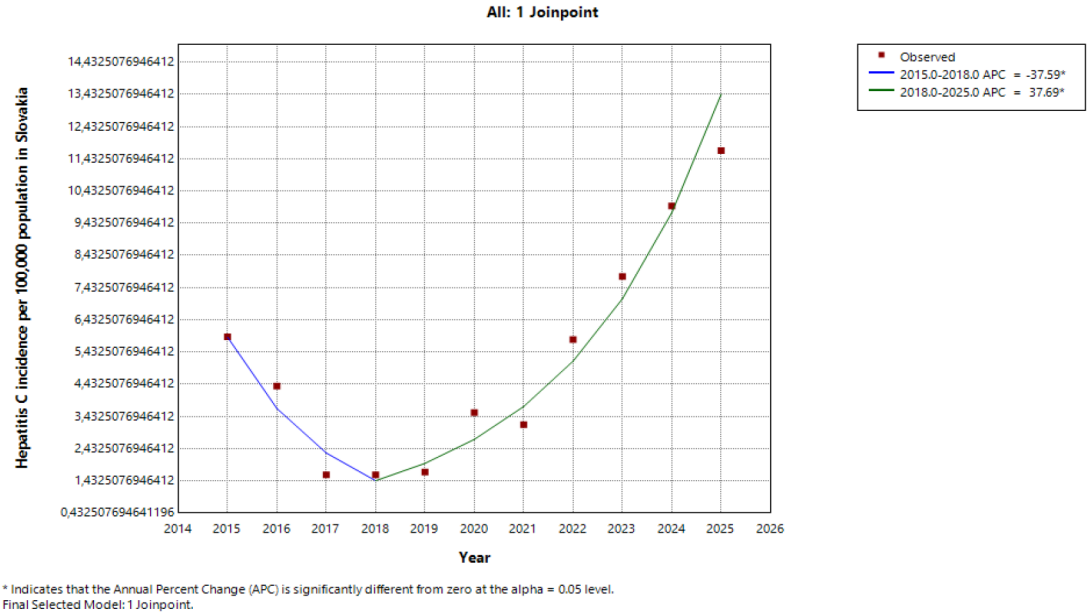

Fig. 3. Trends in hepatitis C incidence in Slovakia, 2015–2025 (Joinpoint regression analysis)

Source: author's own processing

through field-based screening in marginalised communities in 2024–2025.

In 2024, five HCV-positive cases were detected, mainly in the districts of Lučenec and Zvolen. Specifically, cases were identified in Zvolenská Slatina (Zvolen district, $n = 1$) and in the Lučenec district (Divín $n = 1$, Šávoľ $n = 1$, Lučenec $n = 2$) (Figure 4).

In 2025, the highest number of cases was observed in the Lučenec district ($n = 5$), followed by Rimavská Sobota ($n = 2$).

Lučenec represents a high-risk area with a higher proportion of socially disadvantaged populations (Figure 5).

Discussion of research results

The present study provides a comprehensive overview of temporal and spatial patterns of hepatitis C in Slovakia, with a particular focus on the Banská Bystrica Region. The findings demonstrate an increasing trend in HCV incidence over time, accompanied by geographical clustering of cases in specific districts.

The observed increase in incidence is consistent with trends reported across European countries, where fluctuations in HCV reporting have been linked to changes in testing practices and healthcare accessibility [7].

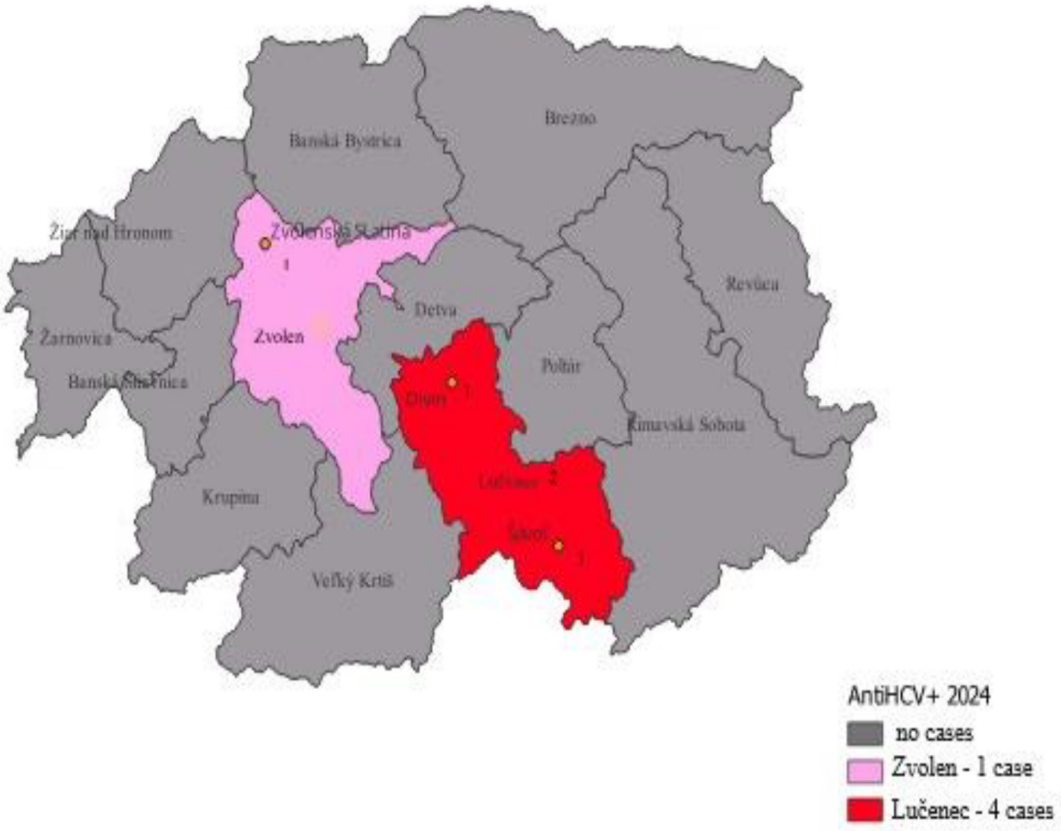

Fig. 4. Geographical distribution of HCV cases in 2024

Source: author's own processing

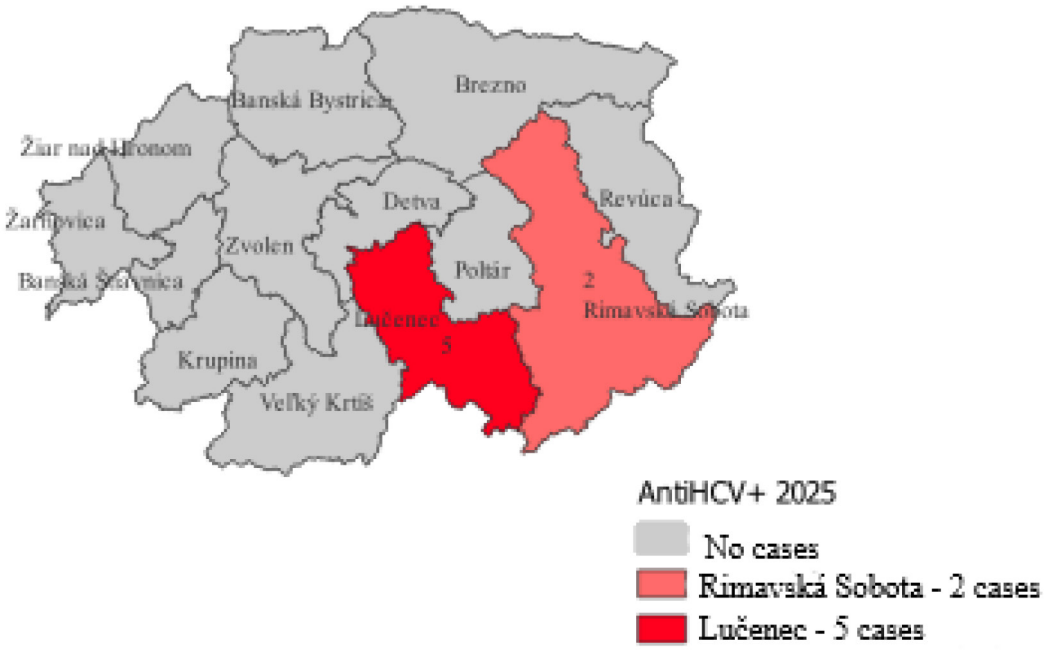

Fig. 5. Geographical distribution of HCV cases in 2025

Source: author's own processing

Variations in surveillance data may reflect both true increases in transmission and improved case detection following disruptions during the COVID-19 pandemic [8]. In this context, the increasing trend identified in the present study, particularly in recent years, may be partially explained by the restoration of screening and diagnostic activities [3].

Spatial analysis revealed clustering of anti-HCV positive cases, predominantly in the Lučenec district. This finding highlights the importance of local epidemiological context, as regional disparities in HCV distribution are often associated with socioeconomic inequalities and reduced access to healthcare [9; 10]. Marginalised populations remain disproportionately affected by HCV infection due to structural barriers in prevention and treatment services [8–10].

Previous studies have reported higher anti-HCV positivity among men, particularly due to increased exposure to behavioural risk factors such as injecting drug use [8]. Health literacy and educational level may influence participation in screening and preventive behaviours [11; 12].

A major strength of this study is the combination of surveillance data with community-based screening, allowing for a more comprehensive understanding of both diagnosed and previously undetected cases. However, the findings should be interpreted with caution due to the relatively small sample size and the targeted nature of the study population.

Overall, the results emphasise the need for continued epidemiological surveillance, expansion of screening programmes, and targeted interventions in high-risk regions. These findings are in line with European data highlighting gaps in hepatitis testing and the need for improved access to diagnostic services across EU/EEA countries [13]. Targeted prevention strategies, particularly among high-risk groups such as people who inject drugs, remain essential for reducing transmission [14].

The concept of micro-elimination, focusing on targeted interventions in specific populations and regions, has been increasingly promoted as an effective strategy for achieving hepatitis C elimination goals [15]. Current clinical guidelines also stress the importance of expanding testing and treatment coverage in order to reduce the burden of disease and prevent further transmission [16].

The findings of this study have important implications for public health practice, particularly in the context of targeted screening and micro-elimination strategies in high-risk regions. Strengthening epidemiological surveillance and improving access to diagnostic and preventive services are essential steps toward achieving the WHO goal of eliminating hepatitis C as a public health threat by 2030.

Prospects for further research

Future research should focus on identifying specific risk factors associated with HCV transmission using advanced analytical methods, such as multivariate and logistic regression models.

Further studies are also needed to evaluate the effectiveness of targeted screening and prevention programmes in high-risk regions, particularly within marginalised populations.

Conclusions

This study highlights a sustained increase in hepatitis C incidence in Slovakia, with the Banská Bystrica Region consistently exceeding the national average. The identification of geographical clustering, particularly in the Lučenec district, points to the presence of localised transmission patterns.

These findings underline the need to strengthen region-specific surveillance and expand targeted screening strategies, especially within socially vulnerable populations, in order to effectively contribute to hepatitis C elimination efforts.

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Purpose. The aim of this study was to analyse spatiotemporal trends in hepatitis C incidence in the Banská Bystrica Region and to evaluate the role of community-based screening in the early detection of HCV infection in marginalised populations.

Materials and methods. A community-based cross-sectional study was conducted between 2024 and 2025 in selected districts of the Banská Bystrica Region. Participants were recruited through outreach activities targeting marginalised communities. Data were collected using an anonymous questionnaire assessing socio-demographic characteristics and hepatitis-related knowledge. Anti-HCV antibody testing was performed using a rapid diagnostic test. Temporal trends were analysed using Joinpoint regression, and spatial distribution of cases was assessed.

Results. A total of 278 individuals were tested during community-based screening activities conducted between 2024 and 2025. In 2024, the prevalence of anti-HCV positivity was 2.0 %, increasing to 16.0 % in 2025. The incidence of chronic hepatitis C in the Banská Bystrica Region increased from 15.7 per 100,000 population in 2024 to 17.8 per 100,000 population in 2025. Joinpoint regression analysis identified a decreasing trend in hepatitis C incidence during 2015–2018 (APC −37.6 %; $p < 0.05$), followed by a statistically significant increasing trend during 2018–2025 (APC +37.7 %; $p < 0.05$). Spatial analysis revealed geographical clustering of HCV-positive cases, predominantly in the Lučenec district, followed by Rimavská Sobota.

Conclusions. The findings indicate ongoing HCV transmission in marginalised communities and highlight the importance of community-based screening for early detection. Identification of high-risk areas may support targeted micro-elimination strategies and improve access to diagnostics and care.

Key words: Hepatitis C, Epidemiology, Joinpoint regression, GIS, Marginalised communities, Public health.

Мета. Метою даного дослідження було охарактеризувати епідеміологію гепатиту С в Банськобистрицькому краї шляхом аналізу даних епідеміологічного нагляду щодо тенденцій захворюваності із застосуванням Joinpoint-регресії, а також доповнити ці результати громадсько-орієнтованим утручанням, спрямованим на раннє виявлення інфекції HCV у маргіналізованих групах населення.

Матеріали та методи. Проведено поперечне громадсько-орієнтоване дослідження у 2024–2025 рр. у вибраних районах Банськобистрицького краю (Лученець, Римавська Собота, Ревуца, Зволен, Великий Кртіш). Учасники були залучені за допомогою виїзних (outreach) активностей, спрямованих на маргіналізовані спільноти. Збір даних здійснювався за допомогою анонімної анкети з 19 запитань, яка включала соціально-демографічні характеристики, рівень обізнаності щодо гепатиту та доступ до медичних послуг. Тестування на антитіла до вірусу гепатиту С (anti-HCV) проводилося за допомогою швидкого діагностичного тесту STANDARD Q HCV Ab, який виконували навчені польові працівники. Для обробки даних застосовано описову статистику, а також просторовий аналіз випадків із позитивним результатом.

Результати. Під час громадсько-орієнтованого скринінгу, проведеного у 2024–2025 рр., було протестовано загалом 278 осіб. У 2024 р. поширеність anti-HCV позитивності становила 2,0 %, тоді як у 2025 р. вона зросла до 16,0 %. Захворюваність на хронічний гепатит С у Банськобистрицькому краї зросла з 15,7 на 100 тис населення у 2024 р. до 17,8 на 100 тис населення у 2025 р. Аналіз Joinpoint-регресії виявив спадну тенденцію захворюваності на гепатит С у період 2015–2018 рр. (APC −37,6 %; $p < 0,05$), після чого спостерігалася статистично значуща зростаюча тенденція у 2018–2025 рр. (APC +37,7 %; $p < 0,05$). Просторовий аналіз виявив географічну кластеризацію HCV-позитивних випадків, переважно в районі Лученець, а також у районі Римавська Собота.

Висновки. Отримані результати свідчать про триваючу передачу вірусу гепатиту С у маргіналізованих спільнотах та підтверджують важливість громадсько-орієнтованих підходів до раннього виявлення інфекції. Визначення локальних осередків захворювання може сприяти впровадженню цільових стратегій мікроелімінації та покращенню доступу до діагностики й лікування. Ефективні скринінгові програми у поєднанні з освітніми інтервенціями мають ключове значення для зниження тягаря захворювання на гепатит С.

Ключові слова: гепатит С, епідеміологія, Joinpoint-регресія, ГІС, маргіналізовані спільноти, громадське здоров'я, Словаччина.

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